ASTR340: The Origin of the Universe

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Office hours: 1.00-2.00pm Tues/Thurs
but let me know first that you’re planning to come

TA: Mr. Pat Tamburo
Room: CSS 0255
Office hours: Mon 11.00 am -12.00 pm

NO OPEN LAPTOPS DURING LECTURES
Welcome!

What is this course about?

Logistics

- Textbook, web pages
- Pre-requisites
- Assignments, exams, grading
- Academic integrity
- Semester plan

Discussion

- Cosmogony: myth vs. science
- Why is the sky dark at night?
Cosmology

- The study of the Universe as a whole
  - What does the present-day Universe look like?
  - What was the history of the Universe?
  - What is the future of the Universe?
  - What makes the whole thing “tick”?
- These are clearly big questions!
Textbook & web pages

- Required text: *Foundations of Modern Cosmology* (2nd edition) by Hawley & Holcomb

- Authors’ web page:
  http://www.astro.virginia.edu/~jh8h/Foundations

- Course web page:
  - Information, syllabus, lecture schedule
  - Assignments
  - Past lectures
  - Interesting material (e.g., links to simulations, Nobel lectures)
Pre-requisites

- **Mathematics**
  - High-school algebra and geometry/trig
- **Familiarity with astronomy at ASTR100 level**
  - Course will be fairly self-contained
  - I will use basic astronomy terms freely (e.g. star, planet, galaxy), and will cover some topics quickly
  - Consult chapters 4 and 5 of the textbook for review/refresher, as needed
  - Please ask about anything when you are unsure!
Assignments & Grading

- Assignments:
  - Homeworks: 30%
  - Midterm: 25%
  - Final: 30%
  - Participation/quizzes: 15%
  - TOTAL: 100%

Note: No “extra-credit projects”
Letter grades

Grading by:

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<tr>
<th>Letter grade</th>
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- I will curve final scores for a B median
- This means that homework is important!
Exams

- One mid-term, in class Mar 10\textsuperscript{th}
- Final exam, 8:00-10:00 May 12\textsuperscript{th}
- Special arrangements? Let me know asap
- In event of a REAL EMERGENCY which forces you to miss an exam
  - Contact me prior to the exam if at all possible
  - Document the emergency
Homeworks

- Homework assigned approx. once every 2/3 weeks (6 total)
- HW is collected *at the start of class* on the due date (a week later)
  - Please hand in on time, or document the valid reason why it is late.
  - No credit after the day on which it is due.
  - Missed because of emergency? Document it
Academic integrity

Always:
- Present your own thoughts in your own words
- Cite any references that you use

Never:
- Copy from another student
- Allow other students to copy from you.
- Directly quote any published article unless you also give full credit to that article.

Per campus policy, please write the honor pledge on each assignment.
Topics to cover

- Early history of cosmology
- The laws that govern the Universe
  - Newton’s laws of motion and gravitation
  - Einstein’s Theory of Relativity
- Observations of the Universe
  - The universe is expanding!
  - What does the future hold?
- The Big Bang Theory
  - What is it...
  - ... and why do we think it’s right?
- Physics of the very early universe
Discussion: myth and science in cosmogony

Throughout history, all cultures have sought to make the Cosmos intelligible, imposing order and addressing timeless questions:

- Have the heavens and Earth existed forever?
- Is the Universe unendingly large?
- If not, how did it all begin?
- Will the Universe come to an end?
- How did humans come about, and what is their role in the Universe?

**What are your questions?**

**Cosmogony** = an explanation of the origin and evolution of the Universe

**Cosmology** = the scientific study of the formation, structure, and evolution of the Universe
Creation myths

- Myths may be meant literally or figuratively
- Mythology reflects what is important to a culture, e.g.
  - revolve around seasons, planting & harvesting for agricultural societies
  - involve animals with human characteristics for hunter-gathering peoples
- Creation myths share common themes
  - Use similar imagery to describe origins/formation of the Universe:
    - e.g. creation from seed/egg; supreme craftsman; order from chaos
  - Use past events to explain aspects of the human condition
  - Involve catastrophes and supernatural occurrences
  - Establish relationships among animals, humans, gods
  - Assert the centrality of humans to the Cosmos
Scientific cosmology

- Non-anthropocentric narrative
  - Is based on concept of causality, but not purpose
- Derives from data = objective (reproducible), quantitative observations of the physical world
- For scientists, the word theory means something very serious
- Models/theories are continually re-evaluated based on the scientific method
- To be scientific, a theory must be falsifiable: whole or part may be rejected based on new data
- New data can support an existing theory, but cannot prove it

General Theory

Prediction (deduction)

Observation (+induction)

The real world
The Galaxy

Andromeda

The Universe

Hubble space telescope Ultra Deep Field (S. Beckwith et al.)
The scientific method

What is a “theory”? Let’s start with a hypothesis
- Relevant (explanatory power)
- Consistent (within and without)
- Predictive (qualitative and quantitative)
- Testable (falsifiable)
- Simple (Occam’s razor)

A hypothesis that survives significant tests of many of its predictions can become a theory, and perhaps even a law.
Why is the night sky dark?

- \( A \sim R^2 \), so if there are \( N \) stars in the first shell, there will be \( 2^2 = 4N \) stars in the second shell.

- Stars in the second shell are half the apparent size of stars in the first shell (they are 2x farther), so each one covers \( \frac{1}{4} \) of the area.

- Thus, each shell contributes \( 4N \times \frac{1}{4}A = NA \) the same to the brightness of the night sky independent of distance!
Why is the night sky dark?

Olber’s Paradox
Why is the night sky dark?

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Olber’s Paradox
An online demo

http://carma.astro.umd.edu/AWE/
Next Time...

- Will discuss
  - classical (geocentric) model of the Universe
  - observations and ideas of the Renaissance
- Please read Chapter 1 of the book
- Read Chapter 2 next week
- First HW assigned Thursday next week